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Worcester, Edward Somerset, 2d marquis of.

THE

MARQUIS OF WORCESTER's

CENTURY

OF

INVENTIONS.

TO WHICH IS ADDED,

AN APPENDIX;

CONTAINING AN

HISTORICAL ACCOUNT

OF THE

FIRE-ENGINE FOR RAISING WATER;

WHICH INVENTION

ORIGINATED FROM THE ABOVE WORK.

BY JOHN BUDDLE.

NEWCASTLE:

PRINTED BY S. HODGSON, UNION-STREET.

1813.

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PREFACE.

To the original edition of this little work, here presented to the public, we stand indebted for the Fire-Engine, *the most valuable machine ever yet invented for the purpose of draining mines; and which may, without much impropriety, be called the* primum mobile *of the coal-trade.*

The first, and only edition of this work, being extremely scarce, on account of the bulk of the impression being made a burnt-offering *to the disingenuous principles and sinister views of* Captain Savery, *who wanted to* pirate *the invention; yet the few copies still remaining, with the greatest certainty point out the* Marquis of Worcester *to have been the original author of that incomparable machine, the Fire-Engine; to whose memory, therefore, not only the gentlemen of the coal-trade, but the whole nation, owe a tribute of gratitude for his great mechanical acumen and sagacity; more especially at this time, when nine collieries out of ten in the northern counties could not be wrought without these machines: And the editor hopes to stand excused, at the bar of the public, for offering a new edition of a work to which so much is owing.*

M368102

'Tis curious enough to observe by what slow gradations this machine has arrived at its present state; the most capital improvements hitherto made thereon arising more from accidental occurrences and mere chance, than being the result of philosophical theory: But as the principles of mechanics are now more generally understood, than they were fifty or sixty years ago, we may hope soon to see the FIRE-ENGINE *in a more improved state.—The very great depths to which winnings are now extended, and the large quantities of water required to be drawn, urge the necessity of the most careful scrutiny into the philosophical principles, and the structure and combination of the several component parts of this machine, in order to its being constructed with powers adequate to the desired effect, and at a fair and regular expence.*

Kyo, near Lanchester, June 18, 1778.

A

CENTURY

OF THE

NAMES AND SCANTLINGS

OF SUCH

INVENTIONS,

As at present I can call to mind to have tried and perfected; which (my former notes being lost) I have, at the instance of a powerful friend, endeavoured, now in the year 1655, *to set these down in such a way as may sufficiently instruct me to put any of them in practice.*

——— ARTIS ET NATURÆ PROLES.

LONDON:

PRINTED BY J. GRISMOND, IN THE YEAR
1663.

M368103

TO THE

KING'S MOST EXCELLENT MAJESTY.

SIR,

SCIRE meum nihil est, nisi me scire hoc sciat alter, saith the poet, and I most justly in order to your Majesty, whose satisfaction is my happiness, and whom to serve is my only aime, placing therein my *summum bonum* in this world: Be therefore pleased to cast your gracious eye over this summary collection, and then to pick and choose. I confess, I made it but for the superficial satisfaction of a friend's curiosity, according as it is set downe; and if it might now serve to give aime to your Majesty how to make use of my poor endeavours, it would crown my thoughts, who am neither covetous nor ambitious, but of deserving your Majesty's favour upon my own cost and charges; yet, according to the old English proverb, *It is a poor dog not worth whistling after.* Let but your Majesty approve, and I will effectually perform to the height of my undertaking: Vouchsafe but to command, and with my life and fortune I shall chearfully obey; and *maugre* envy, ignorance, and malice, ever appear

Your Majesty's passionately-devoted,
Or otherwise disinterested Subject
and Servant,
WORCESTER.

TO THE

RIGHT HON. THE LORDS SPIRITUAL AND TEMPORAL;

AND TO THE

KNIGHTS, CITIZENS, AND BURGESSES OF THE HON. HOUSE OF COMMONS,

Now assembled in Parliament.

My Lords and Gentlemen,

Be not startled if I address to all and every of you, this *Century* of summary heads of wonderful things, even after the dedication of them to his most excellent Majesty, since it is with his most gracious and particular consent, as well as indeed no ways derogating from my duty to his sacred self, but rather in further order into it, since your Lordships, who are his great council, and you, gentlemen, his whole kingdom's representatives (most worthy welcome unto him), may fitly receive into your wise and serious considerations, what doth or may publicly concern both his Majesty and his tender-beloved people.

Pardon me, if I say, my Lords and Gentlemen, that it is jointly your parts to digest to his hand these ensuing particulars, fitting them to his palate, and

ordering how to reduce them into practice, in a way useful and beneficial both to his Majesty and his kingdom.

Neither do I esteem it less proper for me to present them to you in order to his Majesty's service, than it is to give into the hands of a faithful and provident steward whatsoever dainties and provisions are intended for the master's diet; the knowing and faithful steward being best able to make use thereof to his master's contentment and greatest profit, keeping for the morrow whatever should be overplus or needless for the present day, or at least to save something else in lieu thereof. In a word, my Lords and Gentlemen, I humbly conceive this *simile* not improper, since you are his Majesty's provident stewards, into whose hands I commit myself, with all properties fit to obey you; that is to say, with an heart harbouring no ambition, but an endless aim to serve my king and country:— And if my endeavours prove effectual, (as I am confident they will) his Majesty shall not only become rich, but his people likewise, as treasures unto him; and his peerless Majesty, our king, shall become both beloved at home, and feared abroad; deeming the riches of a king to consist in the plenty enjoyed by his people.

And the way to render him to be feared abroad, is to content his people at home, who then with heart and hand are ready to assist him; and whatsoever God blesseth me with, to contribute towards the increase of his revenues in any considerable way, I desire it may be employed to the use of his people; that is, for the taking off such taxes or burthens from them as they

chiefly groan under, and by a temporary necessity only imposed on them; which being thus supplied will certainly best content the king, and satisfie his people; which, I dare say, is the continual tend of all your indefatigable pains, and the perfect demonstrations of your zeal to his Majesty, and an evidence that the kingdom's trust is justly and deservedly reposed in you. And if ever Parliament acquitted themselves thereof, it is this of yours, composed of most deserving persons; qualified, I say, with your affection to your prince, and with a tenderness to his people; with a bountiful heart towards him, yet a frugality in their behalfs.

Go on, therefore, chearfully, my Lords and Gentlemen, and not only our gracious king, but the King of Kings will reward you, the prayers of the people will attend you, and his Majesty will, with thankful arms, embrace you. And be pleased to make use of me and my endeavours to enrich them, not myself; such being my only request unto you, spare me not in what your wisdoms shall find me useful,—who do esteem myself, not only by the act of the water-commanding engine, (which so chearfully you have past) sufficiently rewarded, but likewise with courage enabled to do ten times more for the future; and my debts being paid, and a competency to live according to my birth and quality settled, the rest shall I dedicate to the service of our king and country, by your disposals; and esteem me not the more, or rather any more, by what is past, but what is to come; professing really from my heart, that my intentions are to outgo the six or seven hundred thousand pounds already sacrificed, if countenanced

and encouraged by you; ingenuously confessing, that the melancholy which hath lately seized upon me (the cause whereof none of you but may easily guess) hath, I dare say, retarded more advantages to the public service, than modesty will permit me to utter: And now revived by your promising favours, I shall infallibly be enabled thereunto in the experiments extant, and comprized under these heads, practicable with my directions, by the unparalleled workman, both for trust and skill, *Caspar Kaltoff's* hand, who hath been these five and thirty years as in a school under me employed, and still at my disposal, in a place by my great expenses made fit for public service, yet lately like to be taken from me, and consequently from the service of king and kingdom, without the least regard of above ten thousand pounds expended by me, and through my zeal to the common good;—my zeal, I say,—a field large enough for you, my Lords and Gentlemen, to work upon.

The treasures buried under these heads, both for war, peace, and pleasure, being inexhaustible; I beseech you pardon me, if I say so; it seems a vanity, but comprehends a truth; since no good spring but becomes the more plentiful by how much more it is drawn: and the spinner to weave his web is never stinted, but further enforced.

The more then that you shall be pleased to make use of my inventions, the more inventive shall you ever find me; one invention begetting still another, and more and more improving my ability to serve my king and you; and as to my heartiness therein, there needs no addition,—nor to my readiness a spur. And therefore,

my Lords and Gentlemen, be pleased to begin, and desist not from commending me till I flag in my obedience and endeavours to serve my king and country:

For certainly you'll find me breathless first t'expire,
Before my hands grow weary, or my legs do tire.

Yet abstracting from any interest of my own, but as a fellow-subject and compatriot will I ever labour in the vineyard, most heartily and readily obeying the least summons from you, by putting faithfully in execution, what your judgments shall think fit to pitch upon amongst this Century of experiences, perhaps dearly purchased by me, but now frankly and *gratis* offered to you. Since my heart, methinks, cannot be satisfied in serving my king and country, if it should cost them any thing; as I confess when I had the honour to be near so obliging a master as his late Majesty, of happy memory, who never refused me his ear to any reasonable motion; and as for unreasonable ones, or such as were not fitting for him to grant, I would rather to have died a thousand deaths, than ever to have made any one unto him.

Yet whatever I was so happy as to obtain for any deserving person, my pains, breath, and interest imployed therein satisfied me not, unless I likewise satisfied the fees;—but that was in my golden age.

And even now, though my ability and means are shortened, the world knows why my heart remains still the same; and be you pleased, my Lords and Gentlemen, to rest most assured, that the very complacency

that I shall take in the executing your commands, shall be unto me a sufficient and an abundantly-satisfactory reward.

Vouchsafe, therefore, to dispose freely of me, and whatever lieth in my power to perform: First, in order to his Majesty's service; secondly, for the good and advantage of the kingdom; thirdly, to all your satisfactions, for particular profit and pleasure to your individual selves; professing, that in all and each of the three respects, I will ever demean myself as it best becomes,

My Lords and Gentlemen,
Your most passionately-bent fellow-subject in his Majesty's service,
Compatriot for the public good and advantage,
And a most humble servant to all and every of you,
WORCESTER.

A

CENTURY

OF THE

NAMES AND SCANTLINGS

OF

INVENTIONS

BY ME ALREADY PRACTISED.

I.

Several sorts of seals, some shewing by screws, others by gages, fastening or unfastening all the marks at once; others by additional points and imaginary places, proportional to ordinary escocheons and seals at arms, and each way palpably and punctually setting down (yet private from all others, but the owner, and by his assent) the day of the moneth, the day of the week, the moneth of the year, the year of our Lord, the names of the witnesses, and the individual place where any thing was sealed, though in ten thousand several places, together with the very number of lines contained in the contract, whereby falsification may

be discovered, and manifestly proved, being upon good grounds suspected.

Upon any of these seals a man may keep accompts of receipts and disbursements from one farthing to an hundred millions, punctually shewing each pound, shilling, penny, or farthing.

By these seals likewise any letter, though but written in English, may be read and understood in eight several languages, and in English itself to clean contrary and different sense, unknown to any but the correspondent, and not to be read or understood by him neither, if opened before it arrive unto him; so that neither threats, nor hopes of reward, can make him reveal the secret, the letter having been intercepted, and first opened by the enemy.

II.—How ten thousand persons may use those seals to all and every of the purposes aforesaid, and yet keep their secrets from any but whom they please.

III.—A cypher and character so contrived, that one line, without returns and circumflexes, stands for each and every of the 24 letters; and as ready to be made for the one letter as the other.

IV.—This invention refined, and so abbreviated, that a point onely sheweth distinctly and significantly any of the 24 letters; and these very points to be made with two pens, so that no time will be lost, but as one finger riseth the other may make the following letter, never clogging the memory with several figures for

words, and combination of letters; which with ease, and void of confusion, are thus speedily and punctually, letter for letter, set down by naked and not multiplied points. And nothing can be less than a point, the mathematical definition of being *cujus pars nulla*. And of a motion no swifter imaginable than *semiquavers* or *relishes*, yet applicable to this manner of writing.

V.—A way by a circular motion, either along a rule or ring-wise, to vary any alphabet, even this of points, so that the self-same point individually placed, without the least additional mark, or variation of place, shall stand for all the 24 letters, and not for the same letter twice in ten sheets writing; yet as easily and certainly read and known as if it stood but for one and the self-same letter constantly signified.

VI.—How at a window, far as eye can discover black from white, a man may hold discourse with his correspondent, without noise made or notice taken; being, according to occasion given and means afforded, *ex re nata*, and no need of provision beforehand; though much better if foreseen, and means prepared for it, and a premeditated course taken by mutual consent of parties.

VII.—A way to do it by night as well as by day, though as dark as pitch is black.

VIII.—A way how to level and shoot cannon by night as well as by day, and as directly; without a

platform or measures taken by day, yet by a plain and infallible rule.

IX.—An engine, portable in one's pockets, which may be carried and fastened on the inside of the greatest ship, *tanquam aliud agens*, and at any appointed minute, though a week after, either of day or night, it shall irrecoverably sink that ship.

X.—A way, from a mile off, to dive and fasten a like engine to any ship, so as it may punctually work the same effect, either for time or execution.

XI.—How to prevent and safeguard any ship from such an attempt by day or night.

XII.—A way to make a ship not possible to be sunk though shot an hundred times betwixt wind and water by cannon, and should she lose a whole plank, yet in half an hour's time should be made as fit to sail as before.

XIII.—How to make such false decks as in a moment should kill and take prisoners as many as should board the ship, without blowing the decks up, or destroying them from being reducible, and in a quarter of an hour's time should recover their former shape, and to be made fit for any employment without discovering the secret.

XIV.—How to bring a force to weigh up an anchor,

or to do any forcible exploit in the narrowest or lowest room in any ship; where few hands shall do the work of many; and many hands applicable to the same force, some standing, others sitting, and by virtue of their several helps, a great force augmented in a little room, as effectual as if there were sufficient space to go about with an axle-tree, and work far from the centre.

XV.—A way how to make a boat work itself against wind and tide, yea both without the help of man or beast; yet so that the wind or tide, though directly opposite, shall force the ship or boat against itself; and in no point of the compass, but it shall be as effectual as if the wind were in the pupp, or the stream actually with the course it is to steer, according to which the oars shall row, and necessary motions work and move towards the desired port or point of the compass.

XVI.—How to make a sea-castle or fortification cannon-proof, and capable of a thousand men, yet sailable at pleasure to defend a passage, or in an hour's time to divide itself into three ships as fit and trimm'd to sail as before: And even whilst it is a fort or castle they shall be unanimously steered, and effectually be driven by an indifferent strong wind.

XVII.—How to make upon the Thames a floating garden of pleasure, with trees, flowers, banqueting-houses, and fountains, stews for all kind of fishes, a reserve for snow to keep wine in, delicate bathing

places, and the like; with music made with mills; and all in the midst of the stream, where it is most rapid.

XVIII.—An artificial fountain, to be turned like an hour-glass by a child in the twinkling of an eye, it holding great quantity of water, and of force sufficient to make snow, ice, and thunder, with a chirping and singing of birds, and shewing of several shapes and effects usual to fountains of pleasure.

XIX.—A little engine within a coach, whereby a child may stop it, and secure all persons within it, and the coachman himself, though the horses be never so unruly in a full career; a child being sufficiently capable to loosen them in what posture soever they should have put themselves, turning never so short; for a child can do it in the twinkling of an eye.

XX.—How to bring up water balance-wise, so that as little weight or force as will turn a balance will be only needful, more than the weight of the water within the buckets, which counterpoised empty themselves one into the other, the uppermost yielding its water (how great a quantity soever it holds) at the self-same time the lowermost taketh it in, though it be an hundred fathom high.

XXI.—How to raise water constantly with two buckets only, day and night, without any other force than its own motion, using not so much as any force, wheel, or sucker, nor more pullies than one, on which

the cord or chain rolleth with a bucket fastened at each end. This, I confess, I have seen and learned of the great mathematician *Claudius* his studies at *Rome*, he having made a present thereof unto a cardinal; and I desire not to own any other men's inventions, but if I set down any, to nominate likewise the inventor.

XXII.—To make a river in a garden to ebb and flow constantly, though twenty foot over, with a child's force, in some private room or place out of sight, and a competent distance from it.

XXIII.—To set a clock in a castle, the water filling the trenches about it; it shall shew by ebbing and flowing, the hours, minutes, and seconds, and all the comprehensive motions of the heavens, and counterlibation of the earth according to Copernicus.

XXIV.—How to increase the strength of a spring to such an height, as to shoot bumbasses and bullets of an hundred pound weight a steeple-height, and a quarter of a mile off and more, stonebow-wise, admirable for fireworks and astonishing of besieged cities, when, without warning given by noise, they find themselves so forcibly and dangerously surprised.

XXV.—How to make a weight that cannot take up an hundred pound, and yet shall take up two hundred pound, and at the self-same distance from the centre; and so proportionably to millions of pounds.

XXVI.—To raise weight as well, and as forcibly, with the drawing back of the lever, as with the thrusting it forward; and by that means to lose no time in motion or strength. This I saw in the arsenal at Venice.

XXVII.—A way to remove to and fro huge weights with a most inconsiderable strength, from place to place. For example, ten tunne with ten pounds, and less; the said ten pounds not to fall lower than it makes the ten tunne to advance or retreat upon a level.

XXVIII.—A bridge, portable in a cart with six horses, which in a few hours time may be placed over a river half a mile broad, whereon may with much expedition be transported horse, foot, and cannon.

XXIX.—A portable fortification, able to contain five hundred fighting men, and yet in six hours time may be set up, and made cannon-proof, upon the side of a river or pass, with cannon mounted upon it, and as compleat as a regular fortification, and with half-moons and counterscraps.

XXX.—A way, in one night's time, to raise a bulwark twenty or thirty foot high, cannon-proof, and cannon mounted upon it, with men to overlook, command, and batter a town; for though it contain but four pieces, they shall be able to discharge two hundred bullets each hour.

XXXI.—A way how safely and speedily to make an approach to a castle or town-wall, and over the very ditch, at noon-day.

XXXII.—How to compose an universal character, methodical and easy to be written, yet intelligible in any language; so that if an *Englishman* write it in *English*, a *Frenchman*, *Italian*, *Spaniard*, *Irish*, *Welch*, being scholars; yea, *Grecian* or *Hebritian* shall as perfectly understand it in their own tongue, as if they were perfect *English*, distinguishing the verbs from the nouns, the numbers, tenses, and cases, as properly expressed in their own language, as if it was written in *English*.

XXXIII.—To write with a needle and thread, white, or any colour upon white, or any other colour, so that one stitch shall significantly shew any letter, and as readily and as easily shew the one letter as the other, and fit for any language.

XXXIV.—To write by a knotted silk string, so that every knot shall signify any letter, with a comma, full-point, or interrogation, and as legible as with pen and ink upon white paper.

XXXV.—The like by the fringe of gloves.

XXXVI.—By stringing of bracelets.

XXXVII.—By pinked gloves.

XXXVIII.—By holes in the bottom of a sieve.

XXXIX.—By a lattin or plate lanthorn.

XL.—By the smell.

XLI.—By the taste.

XLII.—By the touch.

By these three senses as perfectly, distinctly, and unconfusedly, yea, as readily as by the sight.

XLIII.—How to vary each of these, so that ten thousand may know them, and yet keep the understanding part from any but their correspondent.

XLIV.—To make a key of a chamber-door, which to your sight hath its wards and rose-pipe, but paper-thick, and yet at pleasure, in a minute of an hour, shall become a perfect pistol, capable to shoot through a breast-plate commonly of carbine-proof, with prime, powder, and firelock, undiscoverable to a stranger's hand.

XLV.—How to light a fire and a candle at what hour of the night one awaketh, without rising or putting one's hand out of bed. And the same thing becomes a serviceable pistol at pleasure; yet by a stranger not knowing the secret, seemeth but a dexterous tinder-box.

XLVI.—How to make an artificial bird to fly which way, and as long as one pleaseth, by or against the wind, sometimes chirping, other times hovering, still tending the way it is designed for.

XLVII.—To make a ball of any metal, which thrown into a pool, or pail of water, shall presently rise from the bottom, and constantly shew, by the *superficies* of the water, the hour of the day or night, never rising more out of the water than just to the minute it sheweth of each quarter of the hour; and if by force kept under the water, yet the time is not lost, but recovered as soon as it is permitted to rise to the *superficies* of the water.

XLVIII.—A scrued ascent; instead of stairs, with fit landing-places to the best chambers of each story, with back-stairs within the noell of it, convenient for servants to pass up and down to the inward rooms of them, unseen and private.

XLIX.—A portable engine, in way of a tobacco-tongs, whereby a man may get over a wall, or get up again being come down, finding the coast proving unsecure unto him.

L.—A compleat light, portable ladder, which taken out of one's pocket, may be by himself fastened an hundred foot high to get up by from the ground.

LI.—A rule of gradation, which with ease and

method reduceth all things to a private correspondence, most useful for secret intelligence.

LII.—How to signify words, and a perfect discourse, by jangling of bells of any parish church, or by any musical instrument, within hearing, in a seeming way of tuning it; or of an unskilful beginner.

LIII.—A way how to make and hollow a water-scrue as big and as long as one pleaseth, in an easy and cheap way.

LIV.—How to make a water-scrue tight, and yet transparent, and free from breaking; but so clear, that one may palpably see the water, or any heavy thing, how and why it is mounted by turning.

LV.—A double water-scrue, the innermost to mount the water, and the outermost for it to descend more in number of threads, and consequently in quantity of water, though much shorter than the innermost scrue, by which the water ascendeth, a most extraordinary help for the turning of the scrue to make the water rise.

LVI.—To provide and make that all the weights of the descending side of a wheel shall be perpetually further from the centre than those of the mounting side, and yet equal in number and heft to the one side as the other. A most incredible thing, if not seen, but tried before the late king (of blessed memory) in the *tower*,

by my directions, two extraordinary ambassadors accompanying his Majesty, and the duke of *Richmond* and duke *Hamilton*, with most of the court attending him. The wheel was 14 foot over, and 40 weights of 50 pounds a-piece. Sir *William Balfore*, then lieutenant of the *tower*, can justify it, with several others.—They all saw, that no sooner these great weights passed the diameter line of the lower side, but they hung a foot further from the centre,—nor no sooner passed the diameter-line of the upper side, but they hung a foot nearer. Be pleased to judge the consequence.

LVII.—An ebbing and flowing water-work, in two vessels, into either of which, the water standing at a level, if a globe be cast in, instead of rising it presently ebbeth, and so remaineth until a like globe be cast into the other vessel, which the water is no sooner sensible of, but that vessel presently ebbeth, and the other floweth, and so continueth ebbing and flowing until one or both of the globes be taken out, working some little effect besides its own motion, without the help of any man within sight or hearing: But if either of these globes be taken out with ever so swift or easy a motion, at the very instant the ebbing and flowing ceaseth; for if during the ebbing you take out the globe, the water of that vessel presently returneth to flow, and never ebbeth after, until the globe be returned into it, and then the motion beginneth as before.

LVIII.—How to make a pistol discharge a dozen times with one loading, and without so much as once

new priming requisite, or to change it out of one hand into the other, or stop one's horse.

LIX.—Another way, as fast and effectual, but more proper for carabines.

LX.—A way, with a flask appropriated unto it, which will furnish either pistol or carabine with a dozen charges in three minutes time, to do the whole execution of a dozen shots, as soon as one pleaseth, proportionably.

LXI.—A third way, and particular for muskets, without taking them from their rests to charge or prime, to alike execution, and as fast as the flask, the musket containing but one charge at a time.

LXII.—A way for a harquebuss, a crock, or ship-musket, six upon a carriage, shooting with such expedition, as without danger, one may charge, level, and discharge them sixty times in a minute of an hour, two or three together.

LXIII.—A sixth way, most excellent for sakers, differing from the other, yet as swift.

LXIV.—A seventh, tried and approved before the late king (of ever-blessed memory), and an hundred lords and commoners, in a cannon of 8 inches, half quarter, to shoot bullets of 64 pounds weight, and 24 pounds of powder, twenty times in six minutes; so

clear from danger, that after all were discharged, a pound of butter did not melt, being laid upon the cannon britch, nor the green oil discoloured that was first anointed and used between the barrel thereof, and the engine, having never in it, nor within six foot, but one charge at a time.

LXV.—A way that one man in the cabin may govern the whole side of ship-musquets to the number (if need require) of 2 or 3000 shots.

LXVI.—A way that against several avenues to a fort or castle, one man may charge fifty cannons, playing and stopping when he pleaseth, though out of sight of the cannon.

LXVII.—A rare way likewise for musquetoons fastened to the pummel of the saddle, so that a common trooper cannot miss to charge them, with twenty or thirty bullets at a time, even in full career.

When first I gave my thoughts to make guns shoot often, I thought there had been but one onely exquisite way inventible, yet by several trials, and much charge, I have perfectly tried all these.

LXVIII.—An admirable and most forcible way to drive up water by fire, not by drawing or sucking it up upwards, for that must be, as the philosopher calleth it, *intra sphæram activitatis*, which is but at such a distance. But this way hath no bounder, if the vessels be strong enough; for I have taken a piece of a whole

cannon, whereof the end was burst, and filled it three quarters full of water, stopping and scruing up the broken end, as also the touch-hole; and making a constant fire under it, within 24 hours it burst and made a great crack: So that having a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other. I have seen the water run like a constant fountaine-stream forty foot high, one vessel of water rarified by fire driveth up forty of cold water. And a man that tends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim between the necessity of turning the said cocks.

LXIX.—A way how a little triangle scrued key, not weighing a shilling, shall be capable and strong enough to bolt and unbolt round about a great chest, an hundred bolts through fifty staples, two in each, with a direct contrary motion, and as many more from both sides and ends, and at the self-same time shall fasten it to a place beyond a man's natural strength to take it away; and in one and the same turn both locketh and openeth it.

LXX.—A key with a rose-turning pipe, and two roses pierced through endwise the bit thereof, with several handsomely contrived wards, which may likewise do the same effects.

LXXI.—A key perfectly square, with a scrue turning within it, and more conceited than any of the rest, and no heavier than the triangle scrued key, and doth the same effects.

LXXII.—An escocheon to be placed before any of these locks, with these properties:—

1. The owner (though a woman) may, with her delicate hand, vary the ways of coming to open the lock ten millions of times, beyond the knowledge of the smith that made it, or of me who invented it.

2. If a stranger open it, it setteth an alarm a-going, which the stranger cannot stop from running out; and besides, though none should be within hearing, yet it catcheth his hand, as a trap doth a fox; and though far from maiming him, yet it leaveth such a mark behind it, as will discover him if suspected; the escocheon or lock plainly shewing what monies he hath taken out of the box to a farthing, and how many times opened since the owner had been in it.

LXXIII.—A transmittable gallery over any ditch or breach in a town-wall, with blind and parapet cannon-proof.

LXXIV.—A door, whereof the turning of a key, with the help and motion of the handle, makes the hinges to be of either side, and to open either inward or outward, as one is to enter or go out, or to open in half.

LXXV.—How a tape or ribbon-weaver may set down a whole discourse, without knowing a letter, or interweaving any thing suspicious of other secret than a new-fashioned ribbon.

LXXVI.—How to write in the dark as streight as by day or candle-light.

LXXVII.—How to make a man fly; which I have tried with a little boy of ten years old, in a barn, from one end to the other, on a hay-mow.

LXXVIII.—A watch to go constantly, and yet needs no other winding from the first setting on the cord or chain, unless it be broken, requiring no other care from one than to be now and then consulted with concerning the hour of the day or night; and if it be laid by a week together, it will not erre much, but the oftener looked upon, the more exact it sheweth the time of the day or night.

LXXIX.—A way to lock all the boxes of a cabinet (though never so many) at one time, which were by particular keys appropriated to each lock, opened severally, and independent the one of the other, as much as concerneth the opening of them, and by these means cannot be left opened unawares.

LXXX.—How to make a pistol barrel no thicker than a shilling, and yet able to endure a musquet-proof of powder and bullet.

LXXXI.—A combe-conveyance carrying of letters without suspicion, the head being opened with a needle-scrue, drawing a spring towards them; the combe being made but after an usual form carried in one's pocket.

LXXXII.—A knife-spoon or fork, in an usual portable case, may have the like conveyances in their handles.

LXXXIII.—A rasping-mill for harts-horn, whereby a child may do the work of half a dozen men, commonly taken up with that work.

LXXXIV.—An instrument whereby persons ignorant in arithmetic may perfectly observe numeration and subtractions of all sums and fractions.

LXXXV.—A little ball made in the shape of plumb or pear, being dexterously conveyed or forced into a body's mouth, shall presently shoot forth such and so many bolts of each side, and at both ends, as without the owner's key can neither be opened or filed off, being made of tempered steel, and as effectually locked as an iron-chest.

LXXXVI.—A chair made *a-la-mode*, and yet a stranger being persuaded to sit down in't, shall have immediately his arms and thighs locked up beyond his own power to loosen them.

LXXXVII.—A brass mold to cast candles, in which

a man may make 500 dozen in a day, and add an ingredient to the tallow which will make it cheaper, and yet so that the candles shall look whiter, and last longer.

LXXXVIII.—How to make a brazen or stone head, in the midst of a great field or garden, so artificial and natural, that though a man speak never so softly, and even whispers in the ear thereof, it will presently open its mouth, and resolve the question in *French*, *Latin*, *Welch*, *Irish*, or *English*, in good terms uttering it out of its mouth, and then shut it until the next question be asked.

LXXXIX.—White silk knotted in the fingers of a pair of white gloves, and so contrived without suspicion, that playing at *primero* at cards, one may, without clogging his memory, keep reckoning of all sixes, sevens, and aces, which he hath discarded.

XC.—A most dexterous dicing box, with holes transparent, after the usual fashion, with a device so dexterous, that with a knock of it against the table the four good dice are fastened, and it looseth four false dice made fit for his purpose.

XCI.—An artificial horse, with saddle, and caparisons fit for running at the ring, on which a man being mounted with his lance in his hand, he can at pleasure make him start, and swiftly to run his career, using the decent posture with *bon grace*, may take the ring as

handsomely, and running as swiftly as if he rode upon a barbe.

XCII.—A scrue made like a water-scrue, but the bottom made of iron-plate, spade-wise, which at the side of a boat emptieth the mud of a pond, or raiseth the gravel.

XCIII.—An engine whereby one man may take out of the water a ship of 500 tun, so that it may be calked, trimmed, and repaired, without need of the usual way of stocks, and as easily let it down again.

XCIV.—A little engine, portable in one's pocket, which placed to any door, without any noise but one crack, openeth any door or gate.

XCV.—A double cross-bow, neat, handsome, and strong, to shoot two arrows, either together or one after the other, so immediately that a deer cannot run two steps but if he miss of one arrow, he may be reached by the other, whether the deer run forward, sideward, or start backward.

XCVI.—A way to make a sea bank so firm and geometrically strong, that a stream can have no power over it; excellent likewise to save the pillar of a bridge, being far cheaper than stone walls.

XCVII.—An instrument whereby an ignorant person may take any thing in perspective, as justly, and more than the skilfullest painter can do by his eye.

XCVIII.—An engine, so contrived, that working the *primum mobile* forward or backward, upward or downward, circularly or cornerwise, to and fro, streight, upright or downright, yet the pretended operation continueth, and advanceth, none of the motions abovementioned, hindering, much less stopping the others; but unanimously, and with harmony agreeing, they all augment and contribute strength unto the intended work and operation: And therefore I call this a *semi-omnipotent engine*, and do intend that a model thereof be buried with me.

XCIX.—How to make one pound weight to raise an hundred as high as one pound falleth, and yet the hundred pound descending doth what nothing less than one hundred pound can effect.

C.—Upon so potent a help as these two last mentioned inventions, a water-work is, by many years experience and labour, so advantageously by me contrived, that a child's force bringeth up an hundred foot high an incredible quantity of water, even two foot diameter, so naturally, that the work will not be heard into the next room; and with so great ease and geometrical symmetry, that though it work day and night from one end of the year to the other, it will not require forty shillings reparation to the whole engine, nor hinder ones day work. And I may boldly call it *The most stupendious work in the whole world:* Not only with little charge to drain all sorts of mines, and furnish cities with water, though never so high seated, as well to keep them sweet, running through several streets,

and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions; but likewise supplying rivers with sufficient to maintaine and make them portable from town to town, and for the bettering of lands all the way it runs; with many more advantageous, and yet greater effects of profit, admiration, and consequence. So that deservedly I deem this invention to crown my labours, to reward my expences, and make my thoughts acquiesce in way of further inventions: This making up the whole century, and preventing any further trouble to the reader for the present, meaning to leave to posterity a book, wherein under each of these heads the means to put in execution and visible trial all and every of these inventions, with the shape and form of all things belonging to them, shall be printed by brass plates.

In Bonum Publicum,

ET

Ad majorem DEI Gloriam.

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APPENDIX:

CONTAINING

AN HISTORICAL ACCOUNT

OF THE

FIRE-ENGINE

FOR

RAISING WATER.

APPENDIX, &c.

That the great force of steam was known to the antients, appears from Vitruvius, who in his *Architect. Lib.* I. *Cap.* 6, teaches "*parvulo æolipilæ spectaculo de immanibus ventorum naturæ rationibus judicari posse censuit.*" But the first, I think, who endeavoured to bring this matter to the test of experiment, was our countryman, the great Lord Verulam, who, in a work entitled *Impetus Philosophici,* col. 705, records the following experiment:—

"*Sumsit phialam vitream, quæ fortasse unciam unam capiebat, cujus collum labro latiore reverso erat instructum, eamque dimidiam aqua replevit, et pondus ejus et aquæ contentæ bilance expendit, dein vesicam, quæ circiter pintam continebat, recentem, oleoque bene obturatam, ad os phialæ filo cerato fortiter alligavit, et phialam super carbones candentes collocavit; aqua non ita multo post bullire cœpit, et paulatim vesicam ex omni parte sufflavit, fereque ad rupturam extendit, quod cum fieret, statim vitrum ab igne remotum et super tapetum positum fuit, ne repentino frigore disrumperetur; tum in summo vesicæ acu foramen aperuit, per quod vapor subito erumpebat. Postea vesicam prorsus a phiala removit, et ejus iterum pondus quæsivit, reperitque duorum denariorum pondus*

aquam amasisse; inde collegit, vaporem, qui vesicam implebat, denariorum duorum ponderi æquipollere, ipsumque vaporem aquæ ad corpus aquæ rationem octogecuplam habuisse."

Now, although the above related experiment was so circumstanced as to afford no very accurate result, either with respect to the quantity of water thrown off in steam, or the expansive force of the steam generated; yet it is highly probable that it might be, in some degree, productive of one of the most lucky thoughts that ever entered the human mind:—I mean that thought of raising water by the *force of steam;* which undoubtedly occurred first to that most ingenious nobleman the MARQUIS of WORCESTER.

This suggestion will appear the more reasonable when we consider, that the sage experimenter, the great LORD VERULAM, (after having laid the most permanent foundations for philosophical experiments) died 1626; which was only 29 years prior to 1655, when, the Marquis tells us, he had acquired a knowledge of all the inventions contained in his work; and that, consequently, there can be no doubt of the Marquis having read his Lordship's works, which, at that time, would most certainly make a great deal of noise in the world, and be of a *cast* entirely compatible with the bent of the Marquis's genius.

As the date of the *Century of Inventions,* &c. leaves no room to doubt of the Marquis being the only person to whom posterity stands indebted for the *original hint* of the Fire-Engine,—we shall therefore proceed to give such accounts thereof as the best authors

furnish us with; and first, we shall transcribe *Switzer's* account, as given in his Hydrost. and Hydraul. printed at *London* in 1729.

MR. STEPHEN SWITZER'S *Account of the Invention of the* FIRE-ENGINE; *from his* Hydrost. *and* Hydraul. *Vol.* II. *p.* 325.

"Amongst the several engines which have been contrived for the raising of water for the supply of houses and gardens, none has been more justly surprising than that of raising water by fire; the particular contrivance, and sole invention of a gentleman, with whom I had the honour long since to be well acquainted; I mean the ingenious Captain *Savery*, some time since deceased, but then a most noted engineer, and one of the commissioners of the sick and wounded.

"This gentleman's thoughts (as appears by a preface of his to a little book, entitled *The Miner's Friend*) were always employed in hydrostatics or hydraulics, or in the improvement of water-works; and the first hint from which it was said he took this engine, was from a *tobacco pipe*, which he immersed to wash or cool it, as is sometimes done; he discovered by the rarefaction of the air in the tube, by the heat or steam of the water and the gravitation or impulse of the exterior air, that the water was made to spring through the tube of the pipe in a wonderful, surprising manner; tho' others say, that the learned Marquis of *Worcester*, in his *Century of Inventions*, (which book I have not seen) *see Obs.* 68, gave the first hint for this raising water by fire.

"It was a considerable time before this curious person, who has been so great an honour to his country, could (as he himself tells us) bring this design to perfection, on account of the auckwardness of the workmen, who were necessarily to be employed in the affair; but at last he conquered all difficulties, and procured a recommendation of it from the Royal Society, in *Transact.* No. 252, and soon after a patent from the crown, for the sole making this engine; and I have heard him say myself, that the very first time he played it, was in a potter's house at *Lambeth*, where, tho' it was a small engine, yet it forced its way through the roof, and struck up the tiles in a manner that surprised all the spectators.

"About the year 1699, he wrote a small pamphlet or treatise concerning this engine which I have just now mentioned; wherein he has exhibited a draught of it, as also a particular description of its uses."

Next follows Dr. *Desagulier's* Account, from his Course of *Experimental Philosophy:—London*, printed 1744.

"In the latter end of King *Charles* the Second's reign, the Marquis of *Worcester* published a book, called *A Century of Inventions*, (printed at *London* in 1663) which he described, as having already put some of them in execution, and proposing others as practicable and beneficial; for which he wanted encouragement from the legislature. Several were only hints, and some things he was mistaken in; but one of his proposals in which he is most explicit, is that of raising water by

the force of fire, turning water into steam to press up great quantities of cold water. The words of the Marquis, No. 68, are as follow:

"*An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be as the philosopher calleth it,* intra sphæram activitatis, *which is but at such a distance. But this way hath no bounder if the vessels be strong enough; for I have taken a piece of a whole cannon, whereof the end was burst, and filled it three quarters full of water, stopping and scruing up the broken end, as also the touch-hole; and making a constant fire under it, within* 24 *hours it burst and made a great crack: So that having a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a constant fountain-stream forty foot high, one vessel of water rarified by fire driveth up forty of cold water. And a man that tends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and re-fill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim between the necessity of turning the said cocks.*"

"CAPTAIN SAVERY, having read the Marquis of *Worcester's* book, was the first who put in practice the raising water by fire, which he proposed for the draining of mines. His engine is described in *Harris's* Lexicon, (see the word ENGINE) which being compared with the Marquis of *Worcester's* description, will easily appear to have been taken from him; though

Captain *Savery* denied it, and the better to conceal the matter, bought up all the Marquis of *Worcester's* books that he could purchase in *Pater-noster-row*, and elsewhere, and burn'd 'em in the presence of the gentleman, his friend, who told me this. He said that he found out the power of steam by chance, and invented the following story to persuade the people to believe it, viz. That having drank a flask of *Florence* at a tavern, and thrown the empty flask upon the fire, he called for a bason of water to wash his hands, and perceiving that the little wine left in the flask had filled up the flask with steam, he took the flask by the neck, and plunged the mouth of it under the surface of the water in the bason, and the water of the bason was immediately driven up into the flask by the pressure of the air. Now he never made such an experiment then, nor designedly afterwards, which I thus prove:

"I made the experiment purposely with about half a glass of wine left in the flask, which I laid upon the fire till it boiled into steam; then putting on a thick glove to prevent the neck of the flask from burning me, I plunged the mouth of the flask under the water that filled a bason; but the pressure of the atmosphere was so strong, that it beat the flask out of my hand with violence, and threw it up to the ceiling. As this must also have happened to Captain *Savery*, if ever he had made the experiment, he would not have failed to have told such a remarkable incident which would have embellished his story.

"Captain Savery made a great many experiments to bring this machine to perfection, and did erect

several, which raised water very well for gentlemen's seats; but could not succeed for mines, or supplying towns, where the water was to be raised very high and in great quantities; for then the steam required being boiled up to such a strength, as to be ready to tear all the vessels to pieces. The heat which is sufficient to boil water will produce steam whose spring is of the same strength as common air; but that steam by the removal of the atmosphere and letting it return to press, is only capable of bringing the water up to a little above 30 foot; but for every 32 foot that the water is to be raised higher, the steam must be so many times stronger than the air: For example, if it is to be forced up 90 or 100 foot higher than the receivers, where the steam acts upon it, the steam must be three or four times stronger than the common air; and a great deal stronger than that (perhaps six times stronger) upon the following account: The hot steam striking upon the surface of cold water in the receivers, condenses itself, and thereby becomes uneffectual, till the surface of the water and a small depth of it is warm enough not to condense any more steam; and then (and not before) the water yields to the pressure of the spring of the steam to make it rise. I have known Captain *Savery* at *York*-buildings, make steam eight or ten times stronger than common air; and then its heat was so great, that it would melt common soft solder; and its strength so great as to blow open several of the joints of his machine: so that he was forced to be at the pains and charge to have all his joints soldered with spelter or hard solder.

" These discouragements stopped the progress and improvement of this engine, till Mr *Newcomen*, an ironmonger, and *John Cawley*, a glazier, living at *Dartmouth*, brought it to the present form in which it is now used, and has been near these 30 years.

" Tho' his method differs much from Captain *Savery's*, and the force of the engine is quite different; yet it is wrought by the same power, viz. the expansion of water into steam; and that power is raised by fire."

From the ANNOTATIONS to his 12th LECTURE.

A more particular Account of the Inventors or Improvers of the several Parts of the Fire-Engine.

" About the year 1710, *Thomas Newcomen*, ironmonger, and *John Calley*, glazier, of *Dartmouth*, in the county of *Southampton, (Anabaptists)* made then several experiments in private, and having brought it to work with a piston, &c. in the latter end of the year 1711, made proposals to draw the water at *Griff*, in *Warwickshire;* but their invention meeting not with reception, in *March* following, thro' the acquaintance of Mr *Potter*, of *Broomsgrove*, in *Worcestershire*, they bargained to draw water for Mr *Back* of *Wolverhampton*, where, after a great many laborious attempts, they did make the engine work; but not being either philosophers to understand the reasons, or mathematicians enough to calculate the powers, and to proportion the parts, very luckily by accident found what they sought for. They were at a loss about the pumps, but being so near *Birmingham*, and having the assistance of so many

admirable and ingenious workmen, they soon came to the method of making the pump-valves, clacks, and buckets; whereas they had but an imperfect notion of them before. One thing is very remarkable; as they at first were working, they were surprised to see the engine go several strokes, and very quick together, when after a search they found a hole in the piston, which let the cold water in to condense the steam in the inside of the cylinder, whereas before they had always done it on the outside. They used before to work with a buoy in the cylinder inclosed in a pipe, which buoy rose when the steam was strong, and opened the injection, and made a stroke; thereby they were capable of only giving six, eight, or ten strokes in a minute, 'till a boy, *Humphrey Potter*, who attended the engine, added (what he called *Scoggan*) a catch, that a beam (now called the *Working Plug*) always opened; and then it would go fifteen or sixteen strokes in a minute.

" But this being perplexed with catches and strings, *Mr. Henry Beighton*, in an engine he had built at *Newcastle on Tyne*, in 1718, took them all away, the beam itself simply supplying all much better.

" N. B. About the year 1717, *I communicated to* Mr. Henry Beighton, *the use of the steel-yard over the* PUPPET CLACK, *or safety-valve, which he applied to some engines.*

" The way of leathering the piston was found by accident about 1713; having then screwed a large piece of leather to the piston, which turned up the sides of the cylinder two or three inches; in working it wore

through, and cut that piece from the other, which falling flat on the piston, wrought with its edge to the cylinder, and having been in a long time, was worn very narrow; which being taken out they had the happy discovery, whereby they found that a bridle rein, or even a soft thick piece of rope or match going round, would make the piston air and water-tight.

" *Mr. Beighton's* account of an experiment which he made on the fire-engine, to know what quantity of steam a cubical inch of water produces, which I thought very well worth mentioning here.

" I found by several experiments by a divided steel-
" yard on the puppet or safety-valve on the top of the
" boilers, at *Griff* and *Wassington*, that when the elasti-
" city of steam was just 1lb. avoirdupoids on a square
" inch, it was sufficient to work the engine, and that
" about five pints in a minute would feed the boiler as
" fast as it consumed in boiling and steam for the cy-
" linder, 16 strokes in a minute. *Griff* cylinder held
" 113 gallons of steam every stroke, × by 16 strokes in
" a minute, = 1808 ale gallons; so five pints of water
" produced 1808 gallons of steam, 38.2 cubic inches in
" one pint. Then 38.2 inches : 1808 gallons :: 1
" inch : 47 gallons 3-10ths: Hence it appears 1 cubic
" inch of water by boiling till its elasticity is capable of
" overcoming about $\frac{1}{15}$ of the atmosphere, will make
" 13,338 cubic inches of steam.

" By experiment I have found that out of the educ-
" tion-valve of a 32 inch cylinder, there comes out 1
" gallon each stroke; it is surprising how that steam,
" which is made of about 3 cubic inches of water,

" should heat 1 gallon of cold water, so as to have it " come out scalding hot, which it does, and the cylin- " der in all its upper part is but warm when the piston " is down."

N. B. There seems to be an error in the above number of 38.2 cubic inches in a pint, it certainly should be $35\frac{1}{4}$; which I thought proper enough to mention here.

The above quotations, on account of the period of time at which they were written, give the best historical account of the Fire-Engine now to be met with, notwithstanding they differ in some circumstances; and all the other accounts that I have seen are only mutilations thereof; for which reason I chose to give them in the words of their own respective authors.

Much about the same period of time that Captain *Savery* was going forward with his engine in *England*, *M. Papin*, M. D. and Professor of Mathematics, at *Marbourg*, was in hands with a similar invention; for in the preface to a small work entitled, *Nouvelle maniere d'elever l'Eau par la Force du Feu*, printed at *Cassel* in 1707, he relates, that he had in the year 1698 made a great number of experiments, by order of his *A. S. Charles Landgrave*, of *Hesse*, for *Raising Water by the Force of Fire;* and which he had communicated to many people, and among them to *M. Leibnitz*, who informed him that he had also had the same thought.

Now although *M. Papin* arrogates to himself the honour of having first made experiments on this subject, yet he does not say how, nor with whom the *lucky thought* originated; but acknowledges, that as a similar

idea might have occurred to Captain *Savery*, as well as to others, he ought also to be esteemed as one of the first inventors. *Mons. Papin* afterwards tells us, that he only wants to inform the world that the said *Landgrave of Hesse* was the first person who had formed so useful a design, and by whose order the first experiments on that subject were made.

Whilst *Mons. Papin* laboured in *Germany*, and *Captain Savery* in *England*, in bringing the action of fire into use in the movement of machines, *Mons. Amontons* was also engaged on the same subject in *France;* as if the three nations in *Europe*, who had already made the greatest progress in the sciences, had each furnished a learned man to participate in the glory of so important a discovery.

The design of *Mons. Amontons* was a fire-wheel, (*moulin à feu*) a draught of which, with its description, may be seen in the *Memoires de l'Académie Royale des Sciences, année* 1699. But dying soon after, the world was deprived of seeing his design reduced to practice.

As the machines of *Mons. Papin* were, in management and effect, in no degree comparable with those of *Captain Savery*, and as very little was done on the subject by *Mons. Amontons*, the *English* nation is undoubtedly entitled to the honour of this most happy discovery; and I shall conclude with a translation of *Mons. Belidor's* account of this matter, from his ARCHITEC. HYDRAUL. *Tome* II. *Livre* IV. *Chap.* III. —" Although the *Marquis of Worcester* was the first in *England* who mentioned, in intelligible terms, a machine for raising water by means of fire, in a small tract,

entitled A CENTURY OF INVENTIONS; yet we cannot dispute *Captain Savery* to have been the first who executed these sorts of machines in *Great-Britain;* as is attested by many letters wrote to me, on that occasion, by the gentlemen of the Royal Society there; in one of which mention is also made of *Mr. Newcomen's* having contributed very much to bring it to its present perfection. Another proof that this machine took birth in *England,* and that excels every thing of the kind that hath been tried in *France* and *Germany,* is, that all the fire-engines that have been constructed abroad, have been executed by *Englishmen.*"—Thanks to *Mons. Belidor,* for his impartiality; few foreigners ever giving any applause to our nation, if there was the least reason for arrogating it to their own.

FINIS.

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